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Application of ensemble machine learning techniques to the diagnosis of the combustion in a gas turbine

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Abstract-

This paper describes a method based on the combination of several machine learning techniques, working together in an ensemble, with the aim of continuously monitoring the combustion of a gas turbine in a combined cycle by observing the available exhaust gas temperature measurements and operation condition variables. The goal of this monitoring is the automatic detection of anomalies in the combustion chambers, and possible faults in the measurement thermocouples in the gas turbine as soon as possible. Four gas turbines were studied, each one equipped with twenty-one thermocouples located at the exhaust gas outlet to measure the temperature in each combustion chamber. These sensors are located at the exhaust of the gas turbine, symmetrically distributed on a circle.

The anomaly detection method developed is based on an ensemble that combines models characterizing the normal behavior expected without anomalies but also the analysis of the actual temperatures of the gas turbine. In particular, neural networks and principal component analysis (PCA) have been applied. These models are used to compare the current performance of the gas turbine with past performance in reference periods known as normal operating conditions, in which a homogeneous distribution of exhaust gas temperatures is observed and a functional relationship between these temperatures and the operating variables such as power output must be fulfilled. If the behavior observed is significantly different from what the designed system expects, it is analyzed to find the cause of this anomaly that could be focused on a specific thermocouple or some combustion chambers. The failure will be associated with a combustion chamber failure if several thermocouples from the same combustion chamber are shown as faulty. This is very useful for planning maintenance and for saving time by removing the problem observed. This paper describes the methods used and real cases of application, which have not been applied as a whole independent analysis system in previous researches. The results obtained have validated the strategy proposed.

Gas turbines can fail due to different components, but the main focus of this article will be gas turbines combustor faults.

Index Terms- Machine learning; Neural network; Principal component analysis; Fault detection; Gas turbine

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